

# FINAL REPORT

on  
the investigation of an aviation occurrence on 01.05.2005 which involved an  
ATR 42-300 airplane during scheduled passenger flight from Sofia to  
Vienna.



2005

All materials have been classified under state file number 3/01.05.2005.

**Aircraft Manufacturer:** Avions de Transport Regional (ATR), Toulouse, France

**Date and place of the aviation occurrence:** In climb after overflying NISVA waypoint in Belgrade Flight Information Region, 01.05.2005.

**Notified:** Aircraft Accident Investigation Unit of the Ministry of Transport and Communications of the Republic of Bulgaria, Civil Aviation Administration of the republic of Bulgaria, Bureau d'Enquetes et d'Analyses pour la securite de l'aviation civile (BEA) of France, International Civil Aviation Organization (ICAO).

For the purpose of the investigation of the aviation occurrence a Commission for investigation has been nominated with Order of the Minister of Transport and Communications of the Republic of Bulgaria No: RD-08-214/09.05.2005. An accredited representative was nominated by BEA of France.

**Type of the flight:** Scheduled passenger flight from Sofia (LBSF) to Vienna (LOWW).

### **Summary**

ATR 42-300 took-off for a scheduled passenger flight Sofia- Vienna – Sofia on 01.05.2005 at 05:48:29 h UTC (08:48:29h Local time). After take-off, at altitude of about 300 ft, the first officer noticed on the torque indicator a drop of engine No:2 torque.

The crew executed an “INCORRECT TORQUE INDICATION” checklist and continued the flight.

After the aircraft was transmitted to Belgrade Control and the crew received a clearance to fly directly to PARAK waypoint, the aircraft started to climb to FL 200 in accordance with the clearance as the crew monitored the engine No:2 parameters. When passing FL 150 a master warning light and aural warning sound alerted the crew for fire in engine No:2.

The crew executed the procedures in accordance with aircraft Quick Reference Handbook (QRH), extinguished the fire and after obtaining clearance from Belgrade Control returned for landing at Sofia Airport. The approach and landing were performed with one engine operative and were uneventful. The crew and the passengers were uninjured.

In accordance with §3 of the Additional Provisions of the Regulation No:13 of the Ministry of the Transport dated 27.01.1999 for aircraft accident investigation the aviation occurrence has been categorized as serious incident.

## **FACTUAL INFORMATION**

### **1.1. History of flight**

The task for the flight was assigned by the air operator's management to a crew, comprising captain, first officer and two cabin attendants.

#### **1.1.1. Flight Number – flight 551**

#### **1.1.2. Preparation and description of the flight**

The crew made a preflight briefing for the flight Sofia – Vienna – Sofia at Sofia airport. The slot for departure was set for 05:45h UTC (08:45 Local Time). The crew arrived at the company office at 04:45h UTC (07:45h Local Time) and received meteorological and navigational information, flight plan, weight of the airplane, number of passengers and fuelling. The captain and the first officer arrived at the AIS office at Sofia airport in order to receive navigational and meteorological information and the flight documents. The cabin attendants were also briefed. The captain was the flying pilot in Sofia – Vienna segment of the trip.

The crew performed a preflight check of the airplane during which no remarks were made. The first officer prepared the cockpit and performed the preflight airplane system test with no remarks. The boarding of the 35 passengers were executed under first officer's supervision.

At the immediate preflight briefing the captain defined the take-off parameters and after receiving the start up clearance from Sofa TWR, he started the engines, rolled toward RWY 09 of Sofia Airport. After being cleared for take-off, the captain took-off from Sofia Airport at 05:48:29h UTC.

On the climb phase during execution of the standard operating procedures and after gear retraction at altitude of approximately 300 ft. the first officer noticed on the TORQUE indicator a drop in the engine No:2 (RH engine) torque which was 66% instead of 91,5%. The first officer reported to the captain about that observation.

The captain decided to execute INCORRECT TORQUE INDICATION checklist on page 2.07 in the QRH. The first officer informed the captain about the relevant procedures following that kind of failure. The captain decided to continue the flight because the Minimum Equipment List (MEL) permits the return flight to be executed with inoperative torque indicator.

On the phase of climb to FL 200 at FL 150 in Belgrade FIR a MASTER WARNING LIGHT came on, the aural warning sounded, followed by signal light "ENGINE 2 OIL" on the CAP and signal light for engine oil low pressure. The captain ordered the first officer to read and execute "ENGINE OIL LO PR" checklist.

When the first officer started to read the checklist the MASTER WARNING light came on again, the aural warning sounded and the following lights came on: "ENG 2 FIRE" on the CAP, "FUEL SO" on the CL, red indication on engine No:2 FIRE HANDLE and on the CL 2 before it was moved to "FUEL SO" position.

The crew executed an "INFLIGHT ENG FIRE" emergency procedure. The fire was extinguished using bottle No:1 agent and the captain decided to turn back for landing at Sofia Airport. After obtaining a clearance from Belgrade Control the aircraft descended with single engine operative.

Sofia Approach was informed by the crew about the fire in engine No:2, which had been extinguished and the fact that the aircraft will land with single engine operative.

Because of the better weather conditions the captain was cleared for landing on RWY 27 at Sofia Airport.

The landing was uneventful. The passengers and the crew were uninjured.

### 1.1.3. Location of the occurrence

The event occurred at 06:07h UTC, daylight, in flight, after overflying NISVA waypoint in Belgrade FIR at FL 150 in climb to FL 200.

## 1.2. Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	0	0
None	4	35	

## 1.3. Damage to aircraft

All the damages have been limited to the RH engine and RH engine nacelle and they are as follows:

- Burned and rubbed blades and missing segments from LPT blades and the PT of the engine;
- Damaged oil vent line from bearing supports No:6 and 7;
- Burns of the electrical insulation of the cables located in the area of the RH engine turbine;

The damages in the area of the RH engine nacelle and the damaged oil vent line are shown on Figures 1.1, 1.2 and 1.3 in Attachment 1.

#### **1.4. Other damages**

No other damages.

**1.5. Personnel information: Captain** - male, aged 47; **First officer** -male, aged 29; **Chief cabin attendant** - female, aged 42; **Cabin attendant** - female, aged 26.

#### **1.6. Aircraft information**

##### **1.6.1. Airworthiness information**

ATR 42-300, SN 151 was manufactured on 25.07.1989 by Avions de Transport Regional (ATR), Toulouse, France and has a Certificate of Airworthiness No: 1726, issued on 27.02.2003 and valid until 28.02.2006.

The airframe has accumulated 23723 h 26 min total time since new and 29184 cycles since new.

The airplane maintenance is performed in accordance with a Maintenance Program approved by the CAA of the Republic of Bulgaria. The last maintenance performed was A CHECK 2000 FH with the relevant Certificate of Release to service issued on December 2004 at 23228:58 flying hours (in the Certificate of Release to Service the date was omitted). The next maintenance scheduled maintenance has to be performed at 23729 flying hours.

The maintenance was performed by the maintenance organization of the air operator, approved by the CAA of the Republic of Bulgaria (license No: MOA-142/0304).

During the preflight preparation of the aircraft a LINE CHECK was performed which was written in sheet No: 03609 in the aircraft technical logbook. No failures nor dispatches had been written in the logbook. The aircraft was refueled with 2040 kg of fuel.

The aircraft is equipped with two Pratt & Whitney of Canada PW120 engines.

The RH engine involved in the aviation occurrence has serial number 120-124 and has accumulated:

- 27070 h 39 min since new;
- 3615 h 39 min since last overhaul.

In accordance with the above mentioned information it could be concluded that at the moment of the aviation occurrence the aircraft was in airworthy condition.

##### **1.6.2. Airplane performance**

The maximum take-off weight of the airplane in accordance with the Certificate of Airworthiness is 16900 kg. The actual take-off weight of the aircraft for the flight 551 according to the loadsheet is 16088 kg. The balance was within the operational limits and did not influence the occurrence.

##### **1.6.3. Fuel**

Prior to the flight 551 the aircraft was refueled at Sofia Airport with 2040 kg of JET A1 fuel. The onboard fuel was enough for the trip. In the fuel samples taken from the LH and RH wing tanks after the occurrence there were no visible traces from sediments or water.

However the following laboratory analysis of the fuel samples revealed sediments in both fuel samples.

### **1.7. Meteorological information**

At the time of the occurrence the visibility was greater than 10 km, wind 3-5 m/s from North-West, Temperature + 18<sup>0</sup> C, QNH 1019.

### **1.8. Aids to navigation**

Not applicable

### **1.9. Communications**

Standard communication equipment for ATR 42-300.

### **1.10. Airport**

The aviation occurrence occurred in flight at FL 150 in Belgrade FIR after overflying NISVA waypoint.

The airplane took-off and landed at Sofia Airport. The coordinates of airport reference points are: N 42<sup>0</sup> 41,7, E 023<sup>0</sup> 24,5. Airport elevation is 531 m. The airport is equipped with ILS, Cat. II.

### **1.11. Flight data recorders**

After landing at Sofia Airport the information from the flight data recorder has been read-out and analyzed. The data from the read-out are attached in Attachment 2. The flight data recorder of ATR 42-300 records 12 analogue and 12 discrete parameters.

### **1.12. Wreckage and impact information**

The serious incident occurred in flight and led as a consequence to landing with single engine operative. The landing was uneventful for the crew, passengers and the aircraft.

### **1.13. Medical and pathological information**

Not applicable.

### **1.14. Fire**

On the phase of climb to FL 200 at FL 150 in Belgrade FIR a MASTER WARNING LIGHT came on, the aural warning sounded, followed by signal light "ENGINE 2 OIL" on the CAP and signal light for engine oil low pressure. The captain ordered the first officer to read and execute "ENGINE OIL LO PR" checklist.

When the first officer started to read the checklist the MASTER WARNING light came on again, the aural warning sounded and the following lights came on: "ENG 2 FIRE" on the CAP, "FUEL SO" on the CL, red indication on engine No:2 FIRE HANDLE and on the CL 2 before it was moved to "FUEL SO" position.

The crew executed an "INFLIGHT ENG FIRE" emergency procedure. The fire was extinguished using bottle No:1 agent and the captain decided to turn back for landing at Sofia Airport. After obtaining a clearance from Belgrade Control the aircraft descended with single engine operative.

The RH engine nacelle has been inspected at Sofia airport. During the visual inspection evident traces of fire and burns of electrical cable insulation were discovered in the combustion chamber area and in the turbine area.

### **1.15. Survival aspects**

Not applicable.

### **1.16. Tests and research**

For the purpose of the technical investigation the following tests and research have been conducted:

- visual inspection of the airplane and the RH engine;
- boroscope inspection of the hot section of the RH engine;
- shop visit in certified maintenance organization for engine repair and overhaul in order to be carried out a complete disassembly of the engine;
- determination of the LP turbine disk unbalance;
- tests of the fuel nozzles spraying;
- inspection of the documentation associated with the flight;
- inspection of the documentation associated with the aircraft airworthiness;
- interview with the flight crew and cabin attendants;
- read-out and analysis of the flight data recorder;
- analysis of BP Turbo oil 2380 oil;
- analysis of the fuel samples JET A1 taken from the LH and RH wing tanks.
- analysis of the different hypothesis for the occurrence;
- meeting with the company management in order to determine the degree of compatibility between the procedures laid down in ATR 42-300 documentation and the conditions of the flight 551.

## **2. Analysis**

The events sequence that led to the occurrence – fire in the RH engine nacelle, abort of the flight and landing at Sofia airport is analyzed herein after.

Thirteen seconds after take-off at 5:48:42 the flight data recorders recorded a considerable drop in engine No:2 LP rotor torque and rotational speed (NL2) – with 24,6% and 8,2% respectively. At this moment the altitude is 288 ft and the airspeed is 114,6 kt. It is to note that the LP rotor rotational speed is recorded by the FDR, but is not displayed on the pilot's displays in the cockpit. The engine No:2 EGT increased with 16,3<sup>0</sup> C and the HP rotor rotational speed practically did not change.

In accordance with the explanation of the first officer he observed a drop in the indications on the TORQUE indicator, which indicated 66% instead of 91,5% and the first officer immediately reported that to the captain. After a crosscheck of both engine parameters which the crew found identical except those of the torque and the EGT the captain decided to follow the procedures laid down in INCORRECT TORQUE INDICATION checklist. This decision was predetermined by the fact that in Part 2 PROCEDURES FOLLOWING FAILURES of the ATR 42-300 Quick Reference Handbook (QRH) in the part for the power plant there is only one procedure corresponding to the decreasing torque and all other engine parameters within the operational limits and this procedure is INCORRECT TORQUE INDICATION. The safety rules impose that only approved procedures have to be followed.

The first officer informed the captain about the actions to be taken according to that procedure in the onboard documentation.

The captain decided to continue the flight because of the fact that according to ATR 42-300 MEL the return flight could be executed with inoperative torque indicator.

The analysis of the events sequence is showing that the above mentioned indication on the engine indicators could be related to failures in the turbomachinery leading to redistribution of the work between the turbine stages and subsequent change of the torque.

This possibility is shown on Figure 110 part 72-00-01, page 124 of PW 120 Operation Manual. Those failures are related with turbine vanes burned, turbine blades rubbed or burned, impellers rubbed or damaged. The presence of such kind of failures has been found

during the boroscope inspection of PW120 engine SN: 120-124. After complete disassembly of the engine performed in EADS SECA facility in France damages and cracks on some of the vanes of the HPT, LPT rotor and stator, PT rotor and stator, shear of bearing No:6 and No:7 housing seal.

Technical Teardown Report issued by the EADS SECA is shown as Attachment 3 to the current report.

Except the drop in the torque the presence of such failures led also to the EGT and vibration increase. The increase of the vibrations is due to the unbalance of the engine rotors, which is a result of the above mentioned failures. In this case there was an increase in the EGT but it could not be perceived by the pilots because the EGT was within the operational limits below 816<sup>0</sup>C.

In the same time ATR 42-300 doesn't have an indicator for vibration measurement in the cockpit. Following the test in EADS SECA facility, the measured unbalance of the LPT disk was 50,6 gr.in, for 11 gr.in maximum which is greater 4,6 times than the maximum prescribed value.

The RH engine continuing run in the conditions of rotor unbalance and vibrations probably led to the damage of the bearing No:6 and No:7 housing seal, followed by oil leakage in the area of the engine hot section and oil pressure drop. As a consequence of the high vibration the oil vent line tube from bearings No:6 and No:7 was also damaged. This damage had been favored by the fall of the clamp that attaches the oil vent line to the nacelle frame. The clamp and its attachment bolt were found during the visual inspection of the combustion chamber and turbine area. The clamp and the bolt are displayed on Figure 4 in Attachment 2. No matter the vibrations it could not be asserted that the fall of the clamp occurred exactly on the last flight because visual inspection of this area has to be carried out on 500 flying hours. This inspection was due to be carried in 6 flying hours after the flight in question. The fall of the clamp led to a decrease of the critical frequencies of the tube.

Oil and oil vapors leaked through the damaged oil vent tube line in the hot engine section, around the combustion chamber and the turbine. The oil flash point according to the test results is 265<sup>0</sup>C. At that moment the engine is running at modes when the EGT is between 740<sup>0</sup>C and 785<sup>0</sup>C. The leaking oil/oil vapors ignited causing fire in the engine nacelle. The fire detection system detected the fire, the crew activated the fire suppression system and extinguished the fire using one bottle of extinguishing agent.

The crew executed appropriately the procedures for a flight with single engine operative and landed uneventfully at Sofia Airport.

In the Technical Teardown Report (Attachment 3) the following conclusions are drawn:

1. The low oil pressure is most probably due to the LPT blades fracture.
2. This LPT blades distress was generated by the High Cycle Fatigue caused by the missing airfoils from the HP Vane ring segments No:1 and No:7.

The burns of the airfoils of HP Vane ring segments No:1 and No:7 most probably is caused by a disturbance in the combustion process in the combustion chamber. In the EADS SECA facility a test of the engine fuel nozzles was performed. The test results are displayed in Attachment 3 of this report. The tests revealed in the 10 out of 14 fuel nozzles there are deviations in their characteristics that are out of the operational limits no matter that they didn't achieve a half of their lifecycles determined by the manufacturer.

A probable cause of those deviations could be the quality of the fuel.

The Commission examined the procedures for fuel quality control followed by the operator. Those procedures are laid down in Air Operator's Manual. In accordance with those procedures on Weekly Check a water tank drain has to be performed and fuel samples have to be taken for analysis. The last documented check dated 29.04.2005. The previous checks have

been performed according to the schedule and the records have been entered in the maintenance documentation.

It is to note that in accordance with the airplane maintenance documentation the task in the task card has been entered as “Draining of water from fuel tank” and does not include a check for sediments as it is laid down in the company’s Air Operator’s Manual.

The procedure for check, control and maintenance of the airplane fuel system filters has been also examined. Last maintenance OOP 2000FH + OOP12 YE was performed on 16.11.2004 and there are no records about fuel filters contamination.

The examination of the fuel suppliers revealed that in 78% of the cases the airplanes of the air operator were refueled by Hemus Air.

An examination of operational practices related to the fuel quality control in other airlines has also been done. This examination showed that on every daily check the air operator Bulgaria Air performs a check for water and sediments in the fuel and on every A check a laboratory analysis for water and sediments in the fuel from the fuel tanks is performed.

### **3. Conclusions**

The technical investigation and the analysis of the serious incident allow drawing the conclusion that the serious incident with flight 551 is a result from the following

#### **Main cause**

Damage of the bearing No:6 and No:7 housing seal and damage of oil vent line tube of the RH engine followed by ignition of the leaked oil and oil vapors in the area of the combustion chamber and the turbine.

#### **Contributory factors:**

1. Sudden increase of the rotor unbalance due to damages in the hot section of the engine.
2. Incompatibility between the procedures following failures in the ATR 42-300 power plant and the flight conditions.
3. Fall of the oil vent line tube attaching clamp of bearings No: 6 and 7.

Considering the causes of the serious incident and the circumstances that led to it, in the process of the investigation the Commission proposed to the CAA of the Republic of Bulgaria the following

#### **Safety recommendations:**

1. Single visual inspection of the engine nacelles of all ATR 42-300 operated by the air operator for the leaks of flammable fluids, for the proper attachment and condition of the tubes, presence and condition of their attachment clamps
2. Single boroscope inspection of the hot section of all PW 120 engines on the aircraft of the air operator. The results of the inspection should be entered in the technical documentation of the engines.
3. The air operator has to develop a decision making procedure for the company’s ATR 42-300 which allows the crew to estimate the possibility of hot section damages in the engine in case of drop in torque indications. After approval by the CAA of the Republic of Bulgaria this procedure should be entered in the Air Operator’s Manual .

Considering the potential hazard which this serious incident could represent for the flight safety the Commission proposes the following

**Safety recommendations:**

1. The air operator should correct its maintenance program and:
  - should include a procedure for visual inspection of the area around the hot engine section at every Weekly check;
  - should include a procedure for chemical analysis for water and sediments in the fuel from the fuel tanks that has to be done at every 250 FH and on every two years a reevaluation of this period has to be done. In case there are no deviations in the fuel parameters this period could be extended to 500 FH (A check);
  - should correct the task card for Weekly Check and should add a visual check for other sediments in position No:3.
2. CAA of the Republic of Bulgaria to perform a complete examination and evaluation of air operator's fuel quality control system.
3. The aircraft manufacturer Avions de Transport Regional, France should introduce a correction in the chapter concerning the powerplant in Part 2 PROCEDURES FOLLOWING FAILURES of the QRH. This correction should consider, in case of drop in the torque indication, the possibility of a hazardous development of the situation due to the damages in the engine turbomachinery.